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The Health Effects Research Laboratory of the U.S. Environmental Protection Agency arranged for several studies, by universities or research institutions, to gather information on health effects associated with wastewater aerosols. Five studies were conducted at wastewater treatment plants and all have been completed. The comprehensive investigations described leave little doubt that working at or living near a wastewater treatment plant does not present a microbiological hazard to the people from the aerosols. However, it should always be kept in mind that sewage contains pathogenic agents and the potential for infection or illness is present.

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HEALTH ASPECTS OF WASTEWATER AEROSOLS

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Recently, emphasis has been placed on wastewater reuse and land application. Spray systems are frequently used to apply the wastewater and, when persons live or work nearby, this raises the question of the health effects from microbial aerosols. In addition, many wastewater treatment plants are constructed in urban areas close to residential areas. These systems generally contain aeration basins or trickling filters where there is an opportunity for small droplets of wastewater to be emitted. These droplets could contain a virus or bacterium and evaporate to yield droplet nuclei in the size range of 1 to 30 microns in diameter. Such particles are known as aerosols.

Numerous persons have studied the microorganisms emitted and their density, in relation to distance from their source. These microorganisms travel passively with the wind and decrease in density as a result of deposition, dispersion, and loss of viability. While the potential exists for persons nearby to inhale viable organisms, until recently there had not been a systematic investivation to confirm or negate the existance of a health hazard.

With this background, the Health Effects Research Laboratory of the U.S. Environmental Protection Agency arranged for several studies, by universities or research institutions, to gather information on health effects associated with wastewater aerosols. Five studies were conducted at wastewater treatment plants and all have been completed. Three health studies are being sponsored to investigate spray irrigation and none have been completed.

The sewage treatment plant investigations may be divided into retrospective studies where basic data already exists and prospective studies where

clinical and environmental samples are collected.

The first investigation utilized data available from a community health study which was carried out over a seven-year period at Tecumseh, Michigan. Illness in the community was related to distance from the activated sludge plant in Tecumseh. Dwelling units around a nonemitting location upwind from the treatment plant were used as a control group. Results showed that both respiratory and gastrointestinal illnesses were greater than expected for persons living within 600 meters of the sewage treatment plant. However, the data suggest the higher rates are related to higher densities of lower socioeconomic families with crowded living conditions rather than to the treatment plant.

In a second retrospective study, illness rates of students at an elementary school, located adjacent to a new advanced wastewater treatment plant, were measured by analyzing recorded absenteeism at this school before and after start-up of the new plant. Attendance at eight nearby schools was used for control rates. There were two sources of aerosols at the treatment plant, the aeration basin of the secondary treatment process and an aerated surge basin used to equalize the flow into the secondary process. Aerosol exposure locations for the children could take place at two locations, the playground area which was within 50 meters of the aerated surge basin, and the classroom area located 400 meters from the aeration basin. On warm days the classroom windows were open.

Detailed examination of school attendance patterns for the two year period prior to the operation of the sewage treatment plant and the two year period following operation revealed no difference for the school next to the treatment plant. Similar comparisons of attendance at this school with the eight other nearby schools showed no differences. Although school attendance is not the most accurate indicator of illness, the data provide no evidence of an adverse health response from the treatment plant.

The first seroepidemiological study was carried out around a new 64,000 cubic meter per day activated sludge plant in the State of Illinois. Persons were evaluated for one year prior to start-up of the treatment plant and one year after operation.

The epidemiological study was divided into two parts. One part consisted of having over 4200 persons who lived between 0.4 and 5.0 kilometers from the

plant answer questions in a questionnaire regarding their illnesses and health status. Detailed statistical analyses were then conducted to determine if results could be related in any way to the operation of the plant. Another part of the study included taking clinical specimens from 282 persons near the plant.

Environmental measurements near the treatment plant indicated that it was a source of indicator bacteria, coliphage, specific pathogenic bacteria, enteroviruses, and mercury in the aerosols emanating from the aeration basins. However, the levels of microbiological or chemical agents of the air, soil, and water samples in the neighboring residential areas were not distinguishable from the background levels.

Based on questionnaire results alone, the responses showed a slight increase in gastrointestinal symptoms after operation of the plant for persons living the nearest distance. Streptococci isolations in the throat swabs also increased. In contrast, tests for 31 viral antibodies and attempted isolations of many pathogenic bacteria, parasites, and viruses yielded no evidence of an adverse health effect from the wastewater treatment plant. On balance, the overall conclusion was that the plant did not present a health hazard for nearby residents.

Another seroepidemiological study was conducted near a one million cubic meter per day sewage treatment plant in Chicago, Illinois. The surface area of sewage exposed to the atmosphere in aeration basins and settling tanks is 55,000 square meters.

Study design was somewhat similar to that described above. A health questionnaire survey was made of 2,378 persons over an eight month period. Stool and throat specimens were collected from children under age 12 for bacteria and virus isolates. A total of 318 persons gave paired blood samples, at the beginning and end of the eight month period, which were tested for antibody to three types of polioviruses, five types of coxsackie B viruses, and four types of echoviruses. Antibody titers in the respective sera obtained at the beginning of the study were used to determine the rates of previous infections by these specific viruses and the number of persons susceptible to each of these agents.

The plant was found to be a source of total viable particles and total coliforms. The coliforms reached background levels at 800 meters while total viable particles were still above background at 800 and 1600 meters.

With regression analysis, no relationship could be found between total viable particle exposure indices and (a) self-reported acute illness rates, (b) pathogenic bacteria isolation rates, (c) prevalence rates of antibody to certain enteroviruses, and (d) virus antibody titers.

In an effort to check persons with the highest exposure to wastewater aerosols, and with the best probability of showing a response, studies were made of wastewater workers. It is recognized that such exposure could be due to direct contact with sewage or handling equipment contaminated by sewage as well as exposure by means of the aerosol route.

A prospective seroepidemiological study was carried out in three metropolitan areas: Cincinnati, Ohio; Chicago, Illinois; and Memphis, Tennessee. The primary study group consisted of about 100 newly employed activated sludge plant workers at the three cities. In addition, in Cincinnati two other groups of about 50 persons each were evaluated, these were sewer maintenance workers and persons who had worked at a primary sewage treatment plant prior to the activated sludge plant work. As additional control groups, water treatment plant workers were selected in Chicago, utility workers in Memphis, and highway maintenance workers in Cincinnati.

Detailed medical tests were conducted on both exposed workers and controls. Factors considered included liver function, immunoglobulin levels, illness rates, blood chemistries, urinalysis, parasitic, bacterial, and viral infections, and antibody to several bacteria and numerous viruses. A serologic survey for viral antibodies of the families of study participants was also conducted to check on the possibility of transmission of infectious agents from the job to the home, and consisted of 87 families of wastewater workers and 41 control families.

The only difference in illness rates among worker groups which was statistically significant was the difference in gastrointestinal illness between inexperienced workers and other groups. Results between experienced workers and controls were not significantly different. These gastrointestinal illnesses were mild and generally appeared within the first several months of employment. There was no relationship between the occurrence of illness and rise of antibody titer for any of the numerous agents checked.

The study failed to demonstrate any differences among groups for immunoglobulin levels or liver function tests. There was no evidence of any increase in hepatitis, as reflected by the liver tests, in workers exposed to wastewater. Stool examinations showed no evidence of increased parasitic infection in the wastewater exposed workers. Isolations of Salmonella and Shigella in rectal swabs were not significantly different between the exposed and non-exposed groups, nor were blood antibody to Salmonella, Leptospira and Legionella pneumophila different. The possibility of an increase in viral infections in wastewater workers was also investigated by means of cultures of throat and rectal swabs and extensive serologic surveys. A major concern in this study was the occurrence of enterovirus infections because of the frequency that enteroviruses can be recovered from sewage. Neither the serologic tests for antibody nor culture results demonstrated a significant increase of viral infections in the wastewater exposed workers. In the study of families, there were no differences between results of the two groups of families.

The comprehensive investigations described leave little doubt that working at or living near a wastewater treatment plant does not present a microbiological hazard to the people from the aerosols. However, it should always be kept in mind that sewage contains pathogenic agents and the potential for infection or illness is present.

One may wonder why, when people have been exposed to microorganisms from the wastewater treatment processes, they did not generally become infected or ill. A combination of several reasons may be offered.

1. The densities of specific pathogens in the aerosols were low, and were reduced rapidly with time and distance from the source.

2. With a respiration rate of approximately one cubic meter per hour, a person would ordinarily inhale very few organisms unless constantly exposed for many hours.

3. The exposure levels were below the minimum infective dose.

4. Microorganisms in wastewater are primarily enteric organisms whereas the route of exposure was respiratory. The proper surface receptor sites for the organisms may not have been available.

5. Nonspecific immunity, which responds quickly to foreign substances, was capable of handling the few microorganisms inhaled. In this situation phagocytic cells, called macrophages and polymorphonuclear leukocytes, tend to engulf the particles from the external environment and subsequently digest them. These actions undoubtedly took place prior to initiation of the specific humoral and cell-mediated immunity response whereby specific antibody and T-cells are formed.

6. Exposed persons were probably in good health and better able to combat infection than would sickly persons.

7. Infectious agents other than those checked may have caused an undetected infection.